Digital Voice: The Next Big Thing

You've Heard About It, But Not Till Now Have You Really Been Inside The World Of Digital Voice

By Don Rotolo, N2IRZ

Digital Voice is the "Next Big Thing," like Plastics in the 1960s and Software in the 1990s. We've been hearing about digital voice for a while, but there's not a lot of information out there—at least, nothing that anyone without a doctorate in mathematics could understand. This article will explain a little about what digital voice is and how it works, provide an overview of the current state of affairs, and offer some resources to learn more and get involved.

Digital voice is simply voice communications using digital technology. At the transmitter side, someone speaks into a microphone. That sound is converted into a digital signal, sent over the air, and decoded back into sound. Exactly how that's done depends on who's doing it, but we'll explore how it works in just a bit.

Digital Advantages

So, what's so great about digital voice? Well, for starters, it's much clearer on the receiving end. Because the audio decoder does not have to also decode atmospheric and other unwanted noises within the desired signal, there is virtually no background noise. That alone accounts for a lot of the great sound of digital voice.

Another way of making the audio sound even better is called Spectral Band Replication (SBR). The high-frequency portions of an audio signal are mostly noise-like, kind of a hissing sound. SBR encodes the loudness and duration of these sounds, and sends that information digitally to the receiver. At the receiver, the SBR decoder just kind of hisses at the right moments. The effect is amazing—your mind really hears a much wider audio range than is actually present.

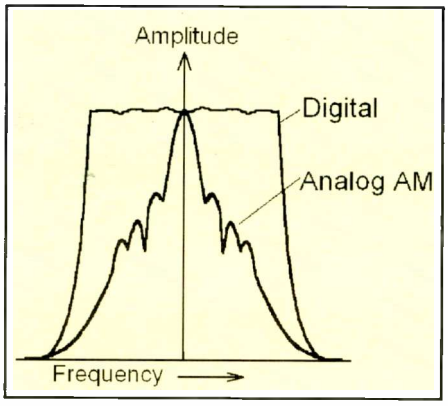

Figure 1. Typical spectrum of a conventional AM signal and of an equivalent digital signal. Because you can put more signal into the same bandwidth, there's less wasted space so the digital signal can be more efficient, which can translate at the receiver into higher fidelity sound and a more noise-proof signal. Note that this is an idealized drawing—the actual digital spectrum depends on the modulation method.

But great audio isn't the biggest advantage of digital voice: signal robustness is. Since the digital voice signal is just a stream of numbers, using some fancy mathematics we can actually make it so that the digital signal can be received perfectly, long after a conventional analog signal has faded into the noise. And, if the communications are two-way, the radios (which are really specialized computers) can adjust themselves automatically to get more and more robust (resistant to noise) as conditions get worse.

Although you need to use a little slice of your digital signal to send some "control data," just the fact that you can hear what is being said is a welcome trade-off against sound quality (which is already better than analog!). Techniques like forward error correction (which allows a damaged signal to repair itself) and error detection are impossible with conventional analog signals.

Digital communications also tend to be more efficient: With digital signals, you can also fill up the available radio channel more completely, so instead of wasting some of your radio channel with dead air, you can fill it up all the way and transfer more "information" as compared to an analog signal.

How It Works

So how does digital voice work? Since parts of this subject have been covered so well elsewhere, such as the turning of voice into a digital data stream as explained in the Audio Digital Recording articles by Joe Cooper (which appeared in *Pop'Comm* just a few months ago), as well as many Web resources that discuss the myriad ways of transmitting digital data streams (like www.tapr.org), I'll just go over the basics.

The real world is analog. When you speak, the sound is continuous, an infinite number of air pressure variations which can be heard and converted to an electrical signal. As an electrical signal, it can be recorded, transmitted by radio, whatever. To turn that electrical signal, say, from a microphone, into digital audio, you read the signal's voltage many thousands of times each second. When you store all those samples, it becomes a representation of that piece of sound. To play it back, you just re-create the voltage for each sample and send that to a speaker; your ears don't hear the "gaps" between the samples because they're too brief.

Since it is represented by numbers, or digits, it is said to be digital, and because it's a representation of sound, or audio, it's

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called digital audio. The numbers are usually represented by binary bits, a stream of ones and zeros which are easily represented with electrical signals, and just as easily worked upon with computers.

Once you have the signal captured in digital form, or *digitized*, you can do whatever you want to it. Mathematicians have a lot of fun with this, since they can enhance or change the signal in literally an infinite number of ways, limited only by the imagination. (I know of a digital audio product which can change your voice to sound like anything, from a duck to Frank Sinatra to a deep rumbling "voice from heaven").

In our case, we're going to assume that, after some relatively tame filtering and shaping, someone will feed those bits to a radio transmitter, and we'll receive it and un-digitize it back into analog sound. That's what we're calling digital voice. Sounds easy, right? Well, on the surface it is, but the devil is in the details.

While one could take a simple Analog-to-Digital (A/D) converter chip—readily available for a few dollars—and digitize the signal, it won't sound very good. Some folks have really studied the human voice, and they have developed special IC chips that can digitize the human voice better through the use of filters and special sampling methods. With digital voice, the goal is to get the best-sounding voice possible with the smallest amount of digital data (measured in bits per second). These special A/D converters, called Vocoders (Voice Encoders) can squeeze a lot of voice out of not many bits.

As you can imagine, there are differently optimized digital encoders for music and other kinds of signals (such as video), but here we're discussing digital human voice, with the intended use of radio communications, and its resulting narrow bandwidth (in terms of bits per second) requirements.

Why Isn't It More Popular?

Why indeed. According to a survey conducted last year by the American Radio Relay League, nearly 62 percent of people surveyed think that digital voice for amateur radio is "just around the corner." In one way, I agree, but there are some practical issues which will slow down the acceptance and use of digital voice for amateur and commercial (non-broadcast) communications.

The first problem is that there's no one standard today for digital voice. Unless you're using a digital decoder that is exactly the right one for the signal you're receiving, you'll probably hear silence. For example, AOR (www.aorusa.com) has come out with their ARD9800 Fast Modem digital voice & image modem, which takes a microphone input and sends a digitized signal to the transmitter (and vice versa on receive). To hear anything, though, you'll have to get a second unit just like it for the receiver.

The AOR ADR8200 digital voice "adapter," sitting atop a typical HF transceiver. This little box takes your voice and turns it into a digital voice signal that can be transmitted through almost any radio. You'll need another one at the receiving end to hear what's being said, however. Although the technology involved is a steal at $500, casual listeners will probably continue to wait for less expensive solutions.

Although it is based on a project published a few years ago by some radio amateurs from Great Britain, and it uses a readily available and inexpensive Vocoder chip, there are too few of them out there to call it a "standard" for digital voice. And, at around $500, few casual users will take a chance and buy one. Despite it being about the only game in town, thus becoming a "de-facto" standard, who knows what'll be on the market in six months? Eventually, someone will make a product that is embraced by enough users to become a true standard, which will attract even more users, who can be sure their investment will not become obsolete too quickly. But, the problem is that we're not there just yet.

The second problem is scanning around for a signal to listen to. Whether you're an SWL listening to the action, or a ham looking for a two-way contact, it's obvious that you need to be able to hear and recognize when you've found a digital voice signal. The problem is that, because of the high efficiency of the Vocoder chips, and their "efficiently filled" signal spectrum, the on-air signal sounds just like white noise or hissing. A digital voice signal (most any digital signal, actually) almost sounds like background noise. When the signal really is below the noise—remember, you can decode a robust digital voice signal from *below* the noise floor—how in the world can you find it?

A third problem is figuring out which decoder to use. Even if you have found a digital signal, you need to start up the correct software program, or connect the correct digital voice decoder box, to be able to hear it. If you guess wrong, you get silence. The only ways I know to figure out what encoding method a digital voice signal might be using is either to try them all (too many possibilities) or to use expensive test equipment, which will help you figure out which dozen or so methods are most likely.

So there, in my view, are the biggest obstacles to an explosion of digital voice communications: The very few digital voice signals that are out there are difficult to find, and listeners can't always be sure how to decode them. And, nobody (to my knowledge) has come up with a set of frequencies where people can meet to play with digital voice. (Perhaps a reader out there knows of some frequen-

cies where digital voice activity is common; if so, please write so we can share that information).

I guess the conclusion we can draw is that digital voice is certainly coming, but it's not quite here yet. I'd imagine that, by the end of 2004, we'll start to see various standards for signal types and frequencies emerge, along with a plethora of software applications, ranging from freeware to very expensive costware, to listen in. One thing should be clear: you'll definitely need a computer and sound card if you're not willing to spend hundreds of dollars on a specialized piece of hardware.

Although I've written about some major issues that have to be resolved before digital voice really takes off, I strongly believe—as do those surveyed by the ARRL—that we're really right at the edge of the explosion in digital voice. Don't let the gloom and doom discourage you, because maybe by listening and trying, *YOU* will be the one who figures out how to tune in a digital signal reliably and figure out the decoder you need. You will never know unless you try.

What's Out There?

To give you the opportunity to try, let's have a look at some of the more popular products on the market. From the broadcast arena, we have DRM and Ibiquity's IBOC. DRM (Digital Radio Mondiale) is a consortium of shortwave broadcasters and equipment manufacturers that has developed and published a standard for digital shortwave broadcasting. It has been accepted by the ITU as a standard, so you'll be hearing about this quite a bit as broadcasters slowly migrate to digital.

The advantages of DRM for broadcasters are a much more robust signal, ability to transmit digital and conventional analog signals on the same channel simultaneously (allowing old and new receivers to be used), and the much higher fidelity of the digital audio signal. Broadcasters can even send digital data in the background, for program information (such as artist and title) or receiver control (to seamlessly switch to another of the various digital signal methods possible, on the fly). Visit www.drm.org, where you can hear some audio samples recorded off the air that are nothing short of astounding, as well as get technical information, broadcast schedules, and even buy the decoding software (www.drmrx.org) to use with your SWL receiver, PC, and sound card.

Ibiquity's IBOC (In-band On-channel) digital broadcast standard is being used by nearly 200 broadcasters, such as WOR-AM (710 kHz New York, www.wor710.com) to transmit analog and digital signals on the same channel, with the same basic advantages of the DRM standard. Although the technical implementation is somewhat different, most of the results are the same. Especially important for the AM broadcasters is the chance to compete with FM radio with comparable audio quality. Although AM radio in North America is mostly talk radio and news, that's about to change in a big way. Visit www.ibiquity.com for information about participating broadcasters and the latest on available receiving equipment.

Of course, there are many other digital voice systems. For instance, Germany was experimenting with digital audio broadcasting and looking for folks to help with testing when I was at the ham radio hamfest in Friedrichshafen, Germany, late last millennium. Chances are your cell phone is using digital voice. There's a lot out there, but of course I can't mention it all.

Gerald Youngblood, AC5OG, discusses the SDR-1000 Software Defined Radio with Ron Block, KB2UYT (left), and Phil Thies, K3TUF (right), at last September's ARRL/TAPR Digital Communications Conference in Connecticut. Inset is the SDR-1000 semi-kit board set. The SDR-1000 is a Software Defined Radio, where all signal processing is performed in software, using a PC sound card. It's much more than a software-controlled or DSP radio (see text for more info).

HF Radio

For HF radio communications—amateur, commercial, and maritime—the AOR fast modem mentioned above offers one of the few solutions today which is compatible with nearly any existing radio. Just plug it in between the microphone and radio and go. A quick Google search for "ARD9800" returned 120 hits, so there's a wealth of info out there. The key to this (and other) HF radio solutions is the low bandwidth requirements—the signal has to be fairly narrow (about 3 kHz) to peacefully co-exist with existing modes and users.

Earlier this year, Thales Communications in France, in collaboration with Ten-Tec here in the United States, stated that a software solution for digital HF voice, based on the DRM standard, would be available later in 2003. An early version of this software was used to make the first two-way HF digital voice contact across the Atlantic Ocean late in November, 2002. You can read more about that, as well as some new receivers and broadcast DRM, at www.tentec.com. At the time this was written the software had not yet been released, but stay tuned.

Although it doesn't actually use digital voice (yet), I have to mention the SDR-1000 Software Defined Radio. It's a $500

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HF transceiver semi-kit, which does all the signal processing in a PC sound card. The reason I mention it is that, since every (!) characteristic of the radio is defined in software, with just a little programming (the PC software is open-source and written in Visual Basic), any moderately competent programmer can write their own digital voice encoder and decoder. In other words, this next-generation radio, which is not just software controlled, but actually defined by software (a mind-boggling concept), is flexible enough to be made to do digital voice of almost any type with just a little effort. Learn more at www.flex-radio.com.

For VHF and UHF communications, a few years ago Alinco sold their EJ-43U digital voice option module for the DJ-596T walkie-talkie, since discontinued. More recently, they have newer radios and a digital voice module (EJ-47U) available (see http://www.alinco.com/usa.html). I participated in an on-air test of a pair of those HTs with Rich Moseson, W2VU Editor of *CQ* magazine, shortly after they became available. Heard on a conventional FM receiver, the digital signal sounded like unsquelched radio noise. On another digital-equipped radio, the sound quality was just a little bit worse than analog FM simplex, and the audio dropped out at around the same signal levels.

While they chose a standard chip set and modulation technique for their digital voice adapter module, Alinco purposely did not incorporate any error correction or significant audio processing to enhance the performance of the digital audio. They specifically stated that they did not intend for this adapter to become some kind of standard; it was developed primarily to give us an opportunity to experiment with the digital world. What I learned was that completely unenhanced digital radio signals will perform much like conventional analog signals and that there are significant opportunities for enhancements to increase range and audio quality, as well as to provide services to radio users which are, again, limited only by your imagination.

Viva La Revolution

So, here we are, right on the edge of yet another revolution in communications. Printing press, telegraph, telephone, spark radio, SSB, FM—and now digital. There's not a lot of plug & play equipment out there...yet. But, in just a few short months, maybe a year or two, we'll see the digital voice snowball get big enough to roll on its own, and then hang on, because it'll be a fun ride.

I've given you a little taste of digital voice, and although it's not as easy to get involved with as, say, broadband radio scanners, just a little effort will return great rewards as you get to be one of the pioneers of the digital revolution. What are you waiting for? ■

Editor's Note: Don is also the Digital editor for CQ magazine and has written for CQ VHF and many club newsletters and publications. In his "Digital Connection" column in the April 2003 issue of CQ, he wrote about the DRM broadcast standard and the historic trans-Atlantic digital voice communication late last year. And in October 2003, he wrote about the SDR-1000. Contact him at Don Rotolo, N2IRZ, PO Box 114, Park Ridge, NJ 07656 or via e-mail at n2irz@cq-amateur-radio.com.